20 Skates and Rays in the Azores and Mid-Atlantic Ridge

20.1 Ecoregion and stock boundaries

The Mid-Atlantic Ridge (MAR; ICES subareas 10.a, b, 12.a1, c, and 14. b1) is an extensive and diverse area, which includes several types of ecosystem, including abyssal plains, seamounts, active underwater volcanoes, chemosynthetic ecosystems and islands.

The main species of elasmobranch observed in this ecoregion are deep-water species (e.g. *Centrophorus* spp., *Centroscymnus* spp., *Deania* spp., *Etmopterus* spp., *Hexanchus griseus*, *Galeus murinus*, *Somniosus microcephalus*, *Pseudotriakis microdon*, *Scymnodon obscurus*, *Centroscyllium fabricii*; see sections 3 and 5 for more information). These species are mostly distributed deeper than 600 m. As a consequence of their low commercial value and EU restrictive management measures, many of these species are discarded (ICES, 2005; WD Pinho and Canha, 2011). The blue shark *Prionace glauca,* thornback ray *Raja clavata* and tope *Galeorhinus galeus* are the most important commercial elasmobranchs species in the Azores area (see sections 4 and 10 for blue shark and tope respectively).

The present section focuses on the skates taken in Azorean waters. Of these, the most abundant in Subarea 10 is thornback ray *Raja clavata*. Other species also observed include the 'common skate complex' (species to be confirmed), *Dipturus oxyrinchus*, *Leucoraja fullonica*, *Rajella bathyphila*, *Raja brachyura* and *Rostroraja alba* (WD Pinho, 2005, 2014b). Other species of batoids, such as Bigelow's ray *Rajella bigelowi* are also observed in this ecoregion (Santos *et al*., 2020a). All these species are generally discarded if caught in the Azorean commercial fisheries (WD Pinho and Canha, 2011). Some of the scarcer skates observed on MAR include *Bathyraja pallida* and *Bathyraja richardsoni* (ICES, 2005).

Stock boundaries are not known for most of the skate species in this area, neither are the potential movements of species that also occur on the continental shelf of mainland Europe. Genetic studies of *R. clavata* have indicated significant differences between Azorean and the eastern Atlantic sea board populations (Chevolot *et al.*, 2006; Ball *et al*., 2016), indicating that mixing is limited. Further investigations are necessary to determine potential migrations or interactions of skate populations within this ecoregion and neighbouring areas.

20.2 The fishery

20.2.1 History the fishery

Two broad types of fisheries occur in the Azores and MAR areas. Oceanic fisheries (large midwater and bottom trawlers and longliners) operate in the central region and northern parts of the MAR. Longline and handline fisheries operate inside the Azorean EEZ, where trawling is prohibited. The latter fishery also targets stocks that may extend south of the ICES area, which southern limit is 36°N.

The fisheries from these areas were described in earlier WGEF reports (ICES, 2005). Landings from the Azorean fleets have been reported to ICES. Landings from the MAR are small and variable, or even absent, and few vessels find the MAR fisheries profitable at present.

Skates are caught in the Azores EEZ by a multispecies demersal fishery, using handlines and bottom longlines, and by the black scabbardfish fishery using bottom longlines (Santos *et al.*, 2020a). The most commercially important skate caught and landed from these fisheries is *R. clavata* (Santos *et al.*, 2020a).

20.2.2 The fishery in 2020

There are no target fisheries for skates in the Azores. An expansion of the Azorean bottom longline fishery to the more offshore seamounts has been observed in the last decade as a result of intensive fishing of important commercial demersal and deep-water stocks and also as a result of the introduction of spatial management measures (Santos *et al.*, 2019).

Skate landings, particularly of *R. clavata,* increased in the Azores since 2009 until 2014. The highest ladings were reported in 2014 and 2015 and the long-term average is 179 t. Landings decreased in the last five years (tables 20.1–20.2; Figure 20.1). Prices in 2017 and 2018 were similar to previous years so that the lowest landing values from the full time series was recorded in 2019. The price of the thornback ray on local market does not seem to vary with quantity landed, suggesting that the market is limited, with little domestic consumption and limited demand for export. Although the fishery for this resource has these characteristics, the species is considered one of the twenty-two priority stocks in Azores (Santos *et al*., 2020b).

There are no fisheries targeting skates on the MAR (ICES subareas 10, 12 and 14) with sporadic landings in recent years (Table 20.1 and 20.2).

20.2.3 ICES advice applicable

For the Rajidae stock in subareas 10 and 12, ICES provides biennial advice. *ICES advises that when the precautionary approach is applied, landings should be no more than 75 tonnes in each of the years 2020 and 2021. ICES cannot quantify the corresponding catches.*

20.2.4 Management applicable

There is no EU TAC for skates and rays in the Azores and Mid-Atlantic Ridge. The only EU management measure susceptible to impact fisheries is the list of prohibited species. Amongst prohibited rays and skates only *Dipturus intermedius* may occur, but is not confirmed, in the stock area, so that the EU management might be considered as having no effect on fisheries.

20.2.4.1 Mid-Atlantic Ridge

NEAFC has adopted management measures for the MAR areas under its regulatory area (https://www.neafc.org/managing_fisheries/measures/current). These include effort limitations, area and gear restrictions.

20.2.4.2 Azores EEZ

In 1998, the Azorean government implemented local management actions in order to reduce effort on shallow areas around the islands, including a licence threshold based on the requirement of the minimum value of sales and the creation of a box of three miles around the islands, with fishing restrictions by gear (only handlines are permitted) and vessel type. During 2009, additional measures were implemented, including area restrictions (temporary closure of the Condor Bank) and gear restrictions by vessel type (licence and gear configuration) (Santos *et al*., 2020a). These technical measures have been updated thereafter (http://www.azores.gov.pt/gra/srmct-pescas/menus/principal/Legislação/).

In 2014, Portugal introduced a new regulation banning the use of bottom trawling and bottom gillnetting on the high seas in the area covered by Portugal's extended continental shelf under the UN Law of the Sea (Portaria n. º 114/2014, 28th May). The new regulation expands the EU regulation adopted in 2005 to ban bottom trawling in the Azores and Madeiran waters and has the key objective of protecting deep-sea ecosystems (such as cold-water corals and seamounts) from the impact of bottom trawling and gillnetting.

Under the EU Common Fisheries Policy, a box of 100 miles was created around the Azorean EEZ where only the Azorean fleets are allowed to line fish for deep-sea species (Regulation EC 1954/2003).

20.3 Catch data

20.3.1 Landings

The landings reported by each country and subarea are given in Tables 20.1–20.2. Historical total landings of skates reported for subareas 10, 12 and 14 are presented in Figure 20.1. Landings data from this ecoregion are also collated by NEAFC, and further studies to ensure that these data are consistent with ICES estimates are required.

20.3.2 Discards

No information on the discarding of skates is available for recent years.

Nevertheless, information on discards from observers in the Azorean longline fishery was reported to the WGDEEP, from 2004 to 2010, (WD Pinho and Canha, 2011). The results showed that *Raja clavata* and 'common skate complex' were among the frequently caught and discarded elasmobranch species.

Discards are probably the result of management measures, particularly the TAC/quotas, minimum size and fishing area restrictions (zoning by fleet characteristics) rather than of the complete lack of market. Management has induced changes in fleet behaviour, expanding the fishing areas to more offshore seamounts and deeper strata. Fisheries occurring outside the ICES area to the south of the Azores EEZ may exploit the same stocks considered here.

20.3.3 Quality of catch data

Species-specific landings data are not currently available for skates landed in this ecoregion, however, more than 90% of the Azorean landings are estimated to be *R. clavata*.

20.3.4 Discard survival

Information on the discard survival of skates in these fisheries is not currently available.

20.3.5 Species composition

In the Azores, there is no systematic fishery/landing sampling programme for these species because they have low priority on the port sampling programme. Landings of skates and rays from Azorean fisheries are reported under generic categories. Accurate data on the composition of skates landed are not currently available.

20.4 Commercial catch composition

20.4.1 Length composition of landings

Length samples of *R. clavata* have been collected since 1990, however few individuals were sampled until 2004 (Figure 20.2; WD Pinho and Pereira, 2017). There are no data available for 2017, 2018, 2019 and 2020 (WD Pinho *et al*., 2019).

20.4.2 Length composition of discards

No information available.

20.4.3 Sex ratio of landings

No information available.

20.4.4 Quality of data

Only limited data are available. Improved data collation and quality checks (including for species identification) are required.

20.5 Commercial catch and effort data

No new information is available.

Relative indices of abundance for the thornback ray species were estimated in 2019 for the period 1990–2017 using a Generalized Linear Modelling approach with a hurdle (delta) model (WD08 Santos *et al*., 2020c) (Figure 20.3). The standardization protocols assumed a hurdle model (zero-altered lognormal) with a binomial error distribution and logit link function for modelling the probability that a null or positive observation occurs (proportion of positive catches), and a lognormal error distribution with an identity link function for modelling the positive catch rates on successful trips.

The trends from the nominal and standardized index differed substantially. Indeed, the nominal CPUE showed an oscillation over time, with an increasing trend from 2007–2015 and decreasing for 2016 and 2017, while the standardized index showed a more stable trend overall (Figure 20.3).

20.6 Fishery-independent surveys

An overview of the elasmobranch species occurring in Azorean waters and ICES Subarea 10, their fisheries and available information on species distributions by depth were described by Pinho (2005; 2014a, b WD), Pinho and Silva (2017 WD) and Santos *et al*. (2020a).

Since 1995, the Department of Oceanography and Fisheries (DOP) has carried out an annual spring demersal bottom longline survey (ARQDAÇO(P)-Q1) around the Azores. In the years 1998, 2006, 2009, 2014 and 2015, no survey was conducted (Pinho et al., 2020). The survey followed a stratified random sampling design in which each sampling area was divided into depth strata with 50 m intervals down to 1200 m depth. Each bottom longline set was deployed perpendicular to the isobaths. Catches per unit of effort were weighted by the corresponding area size to estimate the relative abundance indices (relative population number—RPN; ind. 10^{-3}hooks; Pinho *et al*., 2020) Due to the COVID-19 disruption, the bottom longline survey was not conducted in 2020 and thus there is a lack of fishery sampling data. Given there is no data for 2020, only data up to 2019 were used in the assessment. This survey is not specifically designed to catch elasmobranchs, and so does not provide quantitative information for most species.

Raja clavata is the only common species of skates and rays in this survey (Pinho *et al*., 2020). Only *Dipturus batis* and *Leucoraja fullonica* were caught in more than three longline set during 1996–2018 and their abundance was 20 to 100 times less than that of *R clavata*. Relevant biological information available from the survey was updated in 2019, including the annual abundance index (Figure 20.4) and length–frequency distribution (Figure 20.5). The survey abundance index series is calculated excluding the statistical area VI, corresponding to by western islands (Flores and Corvo), because this statistical area was not sampled in 1996 and 2008 (ICES, 2020).

The absence of records of the youngest size classes in this survey can be attributed to the gear selectivity (Figure 20.5). Catches of other skates are insufficient to be informative of stocks trends.

Information on elasmobranchs recorded on MAR is available from the literature (Hareide and Garnes, 2001) and was summarized in ICES (2005).

20.7 Life-history information

No new information is available. There is poor knowledge of the biology of the species for this ecoregion and available information is uncertain. The definitions of the appropriate set of life-history parameters for this group of species (that best describe population dynamics) and for this ecoregion should be addressed in future work in order to provide more accurate data for exploratory assessments.

20.8 Exploratory assessment methods

Length-based indicators (LBI)

Length-base indicators reported from WKLIFEV were explored for this exercise. The exercise was done for Fishery length composition from 2002–2016 and for the Azorean longline survey length compositions from 1995–2019 (discards were assumed to be negligible). In both scenarios were used pooled sexes for LBI exploratory analysis. Main life-history parameters used are resumed in Table 20.4. Computations were performed using R software and the codes were available in the GitHub library of ICES. Results from the analysis are shown in Figures 20.5–20.6 and Tables 20.5–20.6. Results show that for immature conservation a substantial harvesting occurs before maturity (Lc and L25%<Lmat). This was expected since the current relative exploitation pattern corresponds to a Lc < Lopt and Lmat.

For mature fraction of the population the results suggest that the large individuals are present and with a good conservation status (Lmax>Linf). The Lmat (77.9 cm) is considerably higher than Lopt (61.4 cm) and the results of Pmega indicator clearly suggest that the mega spawners in the fishery landings and Azorean longline survey are higher than 30% throughout the analysed period. However, it is important to note the two last years of the Azorean longline survey, the values of Pmega indicator were lower than 30%.

The MSY proxy results show that exploitation is below the MSY level (Lmean>Lopt and Lmean>LF=M), thus, the exploitation for this species is considered sustainable (Tables 20.5–20.6 and Figures 20.5–20.6).

No assessments have been conducted due to insufficient data.

20.9 Quality of assessments

Analyses of survey trends may be informative for *R. clavata* but do not allow the status of other skates to be evaluated.

20.10 Reference points

No reference points have been proposed for any of these species.

20.11 Conservation consideration

No new information.

20.12 Management considerations

The ecoregion is considered to be a sensitive area. The exploratory analysis demonstrated a sustainable exploitation for these species, but the fishing gear selectivity should be adjusted (increase the size of the hooks).

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Table 20.1. Skates and Rays in the Azores and Mid-Atlantic Ridge. Reported landings (t) from ICES subareas 10 and 12 for the period 1988–2004.

Year	Subarea 10				Subarea 12	Subarea 14
	Portugal (Azores)	France	Spain	Total	UK	UK
1988	48			48		
1989	29			29		
1990	35			35		
1991	52			52		
1992	43			43		
1993	32			32		
1994	55	1		56		
1995	62			62		
1996	71			71		
1997	99			99		
1998	117			117		
1999	103			109		
2000	83		24	107		
2001	68	2	29	99	1	+
2002	70			70	1	+
2003	89			89	6	
2004	72			72	1	

Table 20.2. Skates and Rays in the Azores and Mid-Atlantic Ridge. Reported landings of skates and rays (t) from ICES subareas 10, 12 and 14 for the period 2005–2020.

Year	Subarea 10			Subarea 12		Subarea 14			Total
	Portugal (Azores)	Spain	France	Spain	France	France	Norway	Germany	
2005	47		0.06	0	0.632			0	48
2006	62		0	0	0.029		6.6	0.2	69
2007	71		0	0	0.0135			0.1	71
2008	72		0.063	0	0.0031		0.7	0	73
2009	60		0.16	1.513	0.757		2.5	0	65
2010	68		0.066	5.106	0.275			0	74
2011	91		0.156	1.764	0.358			0	93
2012	103		0.002	0.671	0.26			0	104
2013	115		0.081	0.485	0			0	116
2014	187		0.03	2.481	0.189			0	190
2015	171		0	0	0.055	0.02	0	0	171
2016	127		0	0	0				127
2017	64		0	0	0			0	64
2018	62		0	0	0	0	0	0	61
2019	42		0	0	0	0	3	0	45
2020	60	0	0	0	0.1	0	0	0	60

Table 20.3. Skates and Rays in the Azores and Mid-Atlantic Ridge. Assessment summary. Relative abundance index (catch per unit effort weighted by the size of the strata) of thornback ray (*Raja clavata*) from the Azores (ICES Subarea 10.a2) from the Portuguese bottom longline survey (ARQDAÇO(P)-Q1).

Year	Abundance index	Lower	Upper
1995	10.2	4.5	16.9
1996	7	3.7	10.2
1997	5.1	3.2	6.7
1998	NA	NA	NA
1999	4.7	3.1	6.3
2000	4.0	1.53	6.9
2001	4.3	1.97	6.7
2002	17.2	10.4	25
2003	26	11.1	38
2004	13.4	9.1	18.3
2005	22	9	31
2006	NA	NA	NA
2007	18.0	9.8	27
2008	8.3	4.2	11.9
2009	NA	NA	NA
2010	7.3	4.6	9.9
2011	4.9	2.5	7.5
2012	6.6	4.4	8.9
2013	2.8	1.53	4
2014	NA	NA	NA
2015	NA	NA	NA
2016	3.7	2.3	5.1
2017	8.0	3.6	13.4
2018	4.1	2.3	5.9
2019	12	5.8	16.5
2020	NA	NA	NA

NA = not available.

Table 20.4. Input constant parameters used in LBI analysis for *Raja clavata* of the Azores (ICES Area 10.a.2).

Parameters	Value	Definition	Obs
Loo (cm)	92.16	Asymptotic average maximum length	Santos *et al*. (2021)
k (year^{-1})	0.104	Growth coefficient of the von Bertalanffy growth model	Santos *et al.* (2021)
Lmat (LT, cm)	77.9	Length at size first maturity	Santos *et al.* (2021)
M	0.16	Natural mortality	Santos *et al.* (2021)
M/k	1.55	Ratio of natural mortality and the von Bertalanffy growth coefficient	Santos *et al.* (2021)

Table 20.5. Skates and Rays in the Azores and Mid-Atlantic Ridge. Traffic light indicators for *Raja clavata* from the Azorean fishery landings for the period 2002–2016 (ICES Area 10.a.2).

		Conservation				Optimizing	MSY
		Lc / Lmat	L25% / Lmat	Lmax5% / Linf	Pmega	Lmean / Lopt	Lmean / LF=M
	Reference	> 1	> 1	> 0.8	> 0.3	~ 1 (> 0.9)	≥ 1
Bottom longline	2002	0.79	0.82	0.89	0.52	1.15	1.02
	2003	0.75	0.79	0.92	0.50	1.13	1.04
	2004	0.73	0.76	0.89	0.39	1.10	1.04
	2005	0.67	0.73	0.91	0.40	1.08	1.07
	2006	0.67	0.73	0.90	0.30	1.05	1.04
	2007	0.73	0.79	0.91	0.43	1.11	1.04
	2008	0.75	0.79	0.91	0.46	1.12	1.03
	2009	0.76	0.82	0.92	0.44	1.13	1.02
	2010	0.74	0.74	0.90	0.23	1.07	0.99
	2011	0.80	0.80	0.90	0.49	1.14	1.00
	2012	0.76	0.76	0.92	0.37	1.12	1.01
	2013	0.76	0.78	0.90	0.39	1.12	1.01
	2014	0.74	0.76	0.91	0.38	1.11	1.03
	2015	0.71	0.76	0.89	0.43	1.10	1.04
	2016	0.76	0.78	0.89	0.39	1.11	1.01

Table 20.6. Skates and Rays in the Azores and Mid-Atlantic Ridge.Traffic light indicators *for Raja clavata* from the Azorean spring bottom longline survey for the period 1995–2019 (ICES Area 10.a.2).

		Conservation				Optimizing Yield	MSY
		Lc / Lmat	L25% / Lmat	Lmax5% / Linf	Pmega	Lmean / Lopt	Lmean / LF=M
	Reference	> 1	> 1	> 0.8	> 0.3	~ 1 (> 0.9)	≥ 1
Survey	1995	0.67	0.71	0.87	0.23	1.03	1.01
	1996	0.75	0.80	0.92	0.37	1.10	1.01
	1997	0.94	0.87	0.92	0.75	1.27	1.00
	1998	0.67	0.75	0.95	0.40	1.10	1.08
	1999	0.58	0.62	0.92	0.31	1.02	1.09
	2000	0.48	0.67	0.91	0.41	1.04	1.24
	2001	0.52	0.67	0.93	0.43	1.03	1.18
	2002	0.56	0.60	0.82	0.11	0.90	1.00
	2003	0.57	0.62	0.82	0.11	0.92	1.01
	2004	0.64	0.69	0.85	0.13	0.98	1.00
	2005	0.74	0.75	0.89	0.26	1.07	1.00
	2006	0.66	0.69	0.90	0.21	1.03	1.03
	2007	0.67	0.71	0.88	0.14	1.02	1.00
	2008	0.78	0.80	0.98	0.42	1.15	1.03
	2009	0.67	0.73	0.94	0.22	1.05	1.04
	2010	0.89	0.79	0.91	0.52	1.22	1.00
	2011	0.69	0.74	0.92	0.31	1.07	1.04
	2012	0.80	0.76	0.92	0.51	1.15	1.01
	2013	0.76	0.79	0.92	0.57	1.18	1.07
	2014	0.69	0.76	0.94	0.49	1.13	1.10
	2015	0.69	0.76	0.94	0.49	1.13	1.10
	2016	0.88	0.75	0.94	0.53	1.24	1.03
	2017	0.61	0.71	0.90	0.34	1.05	1.10
	2018	0.69	0.74	0.88	0.30	1.07	1.04
	2019	0.69	0.70	0.82	0.09	1.00	0.98

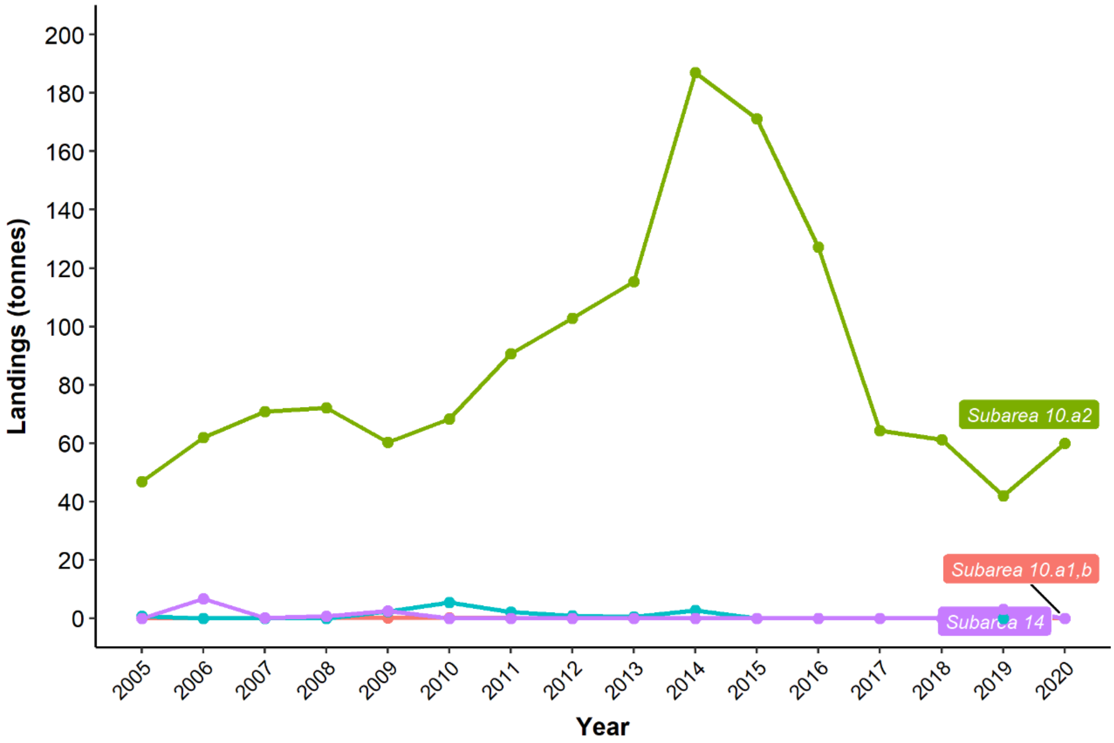

Figure 20.1. Skates and Rays in the Azores and Mid-Atlantic Ridge. Historical landings of skates and rays from Azores (ICES Division 10.a2) and MAR (ICES subareas 10, 12 and 14).

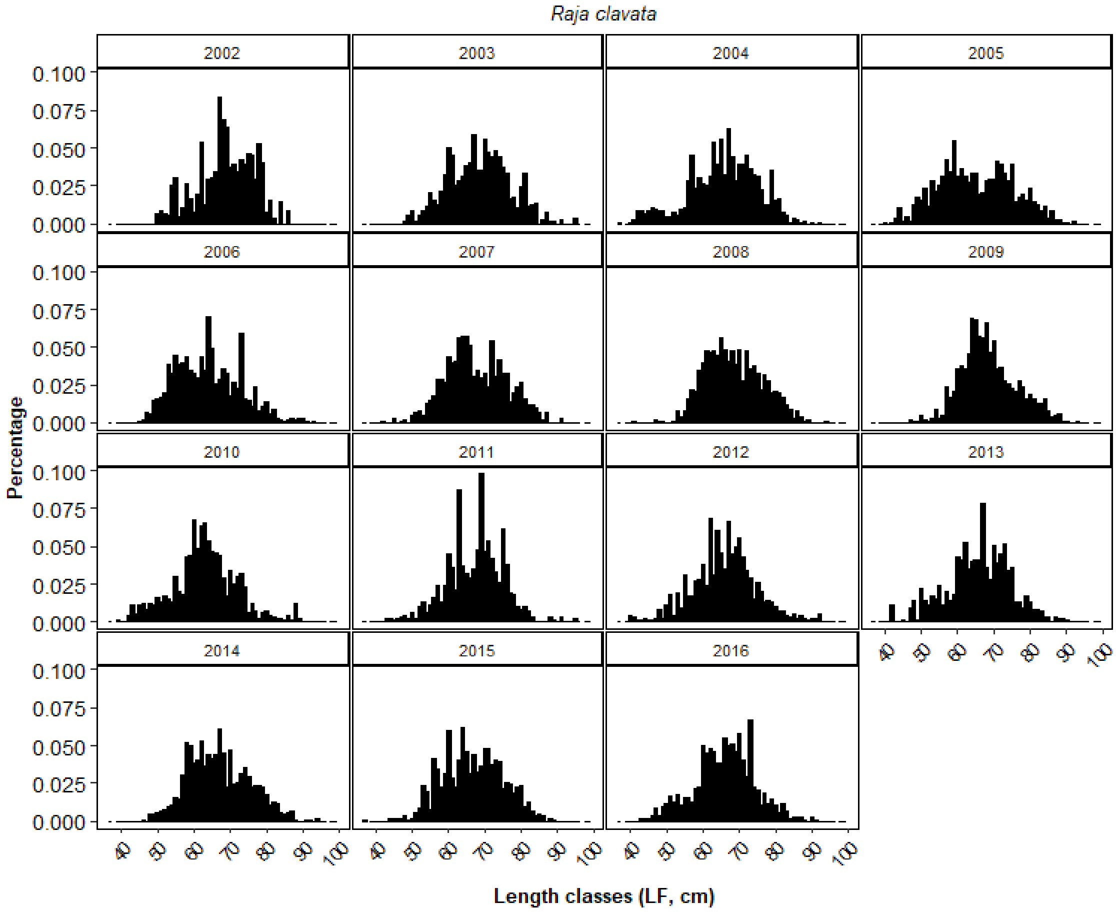

Figure 20.2. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of *Raja clavata* landed in the Azorean for the period 2002–2016.

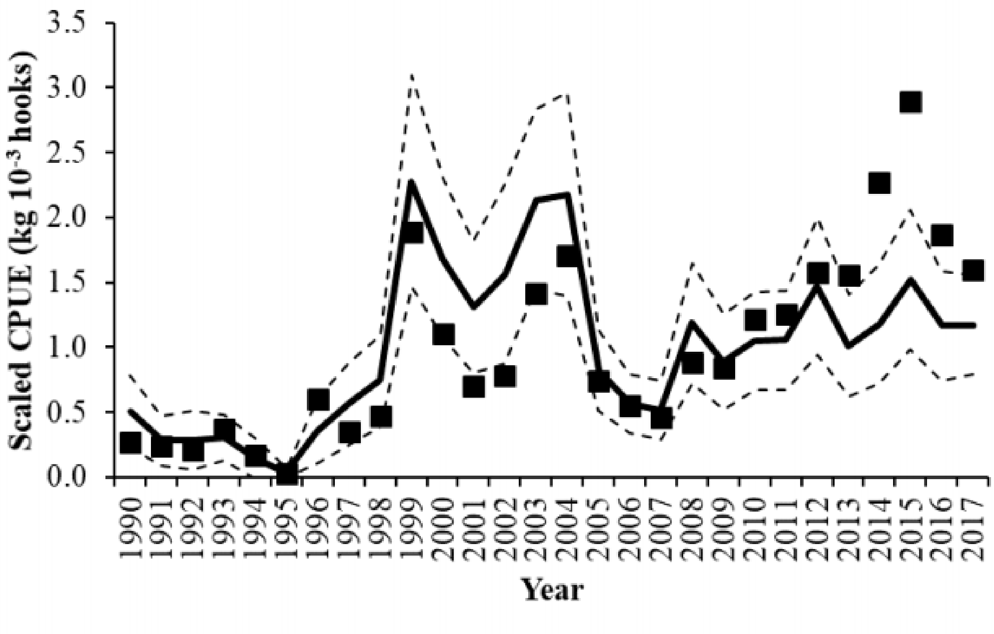

Figure 20.3. Skates and Rays in the Azores and Mid-Atlantic Ridge. Standardized fishery CPUE of *Raja clavata* landed in the Azorean for the period 1990–2017. Square points are observed nominal CPUE; Black line: Standardized CPUE and dashed lined 95% confidence interval.

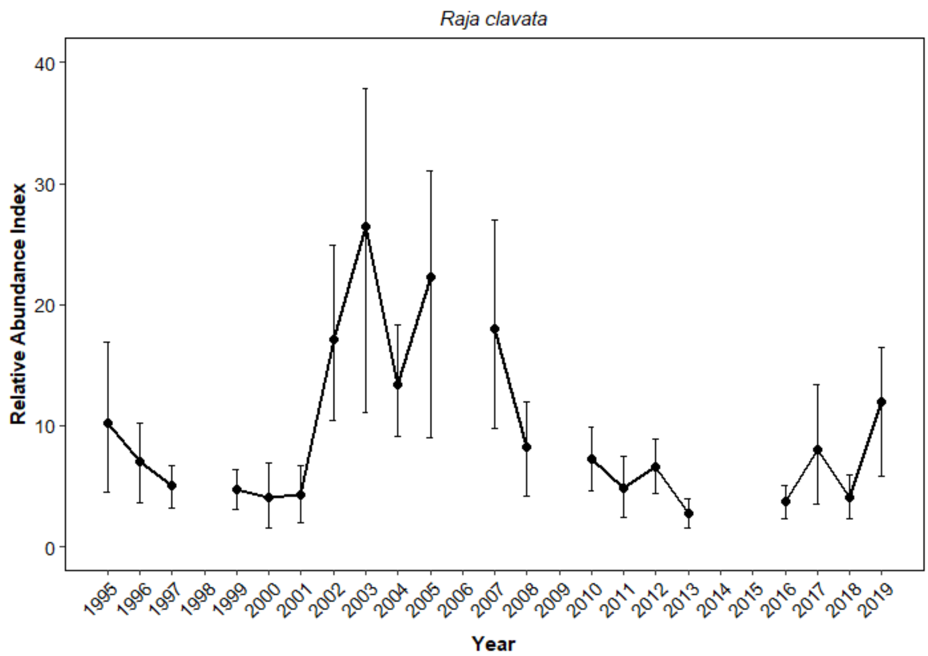

Figure 20.4. Skates and Rays in the Azores and Mid-Atlantic Ridge. Annual abundance, in numbers, of *Raja clavata* from the Azores (ICES subarea 10) from the Azorean demersal spring bottom longline survey (1995–2019).

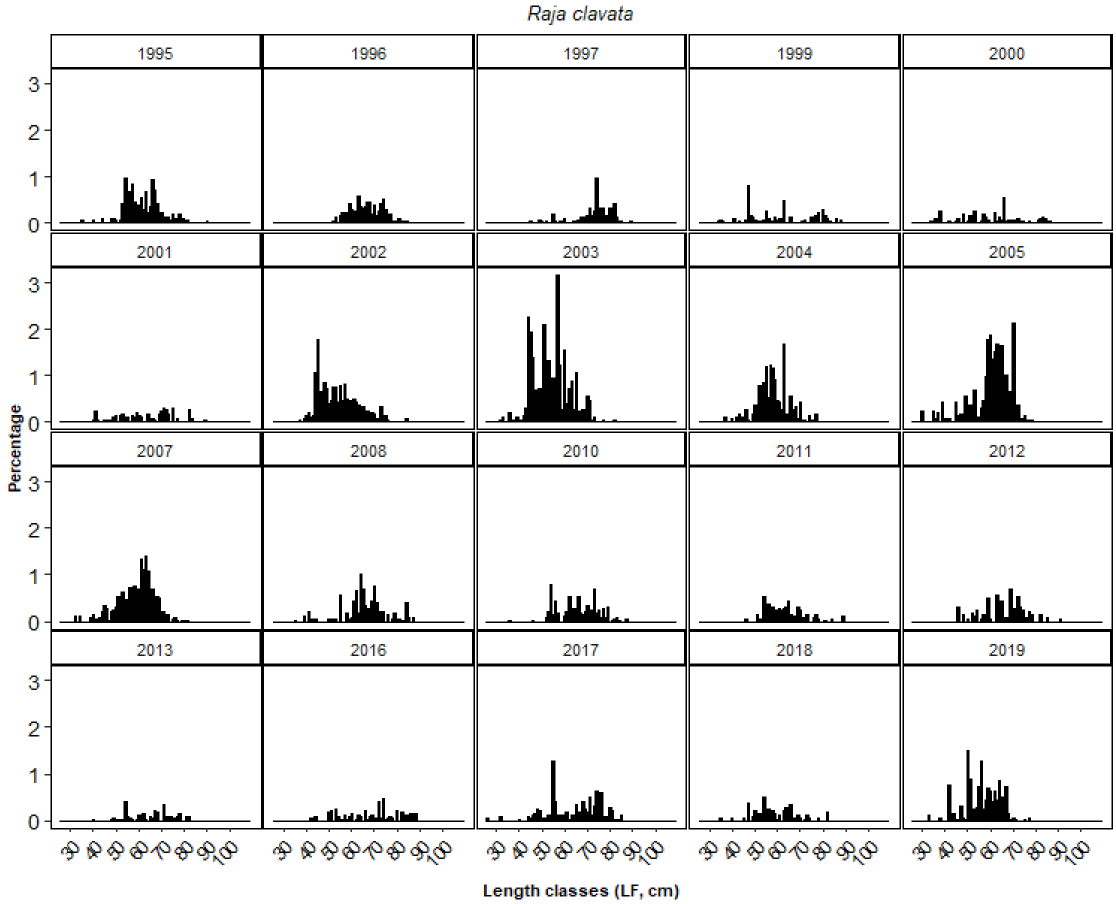

Figure 20.5. Skates and Rays in the Azores and Mid-Atlantic Ridge. Length-frequency of *Raja clavata* caught in the Azorean demersal spring bottom longline survey for the period 1995–2019.

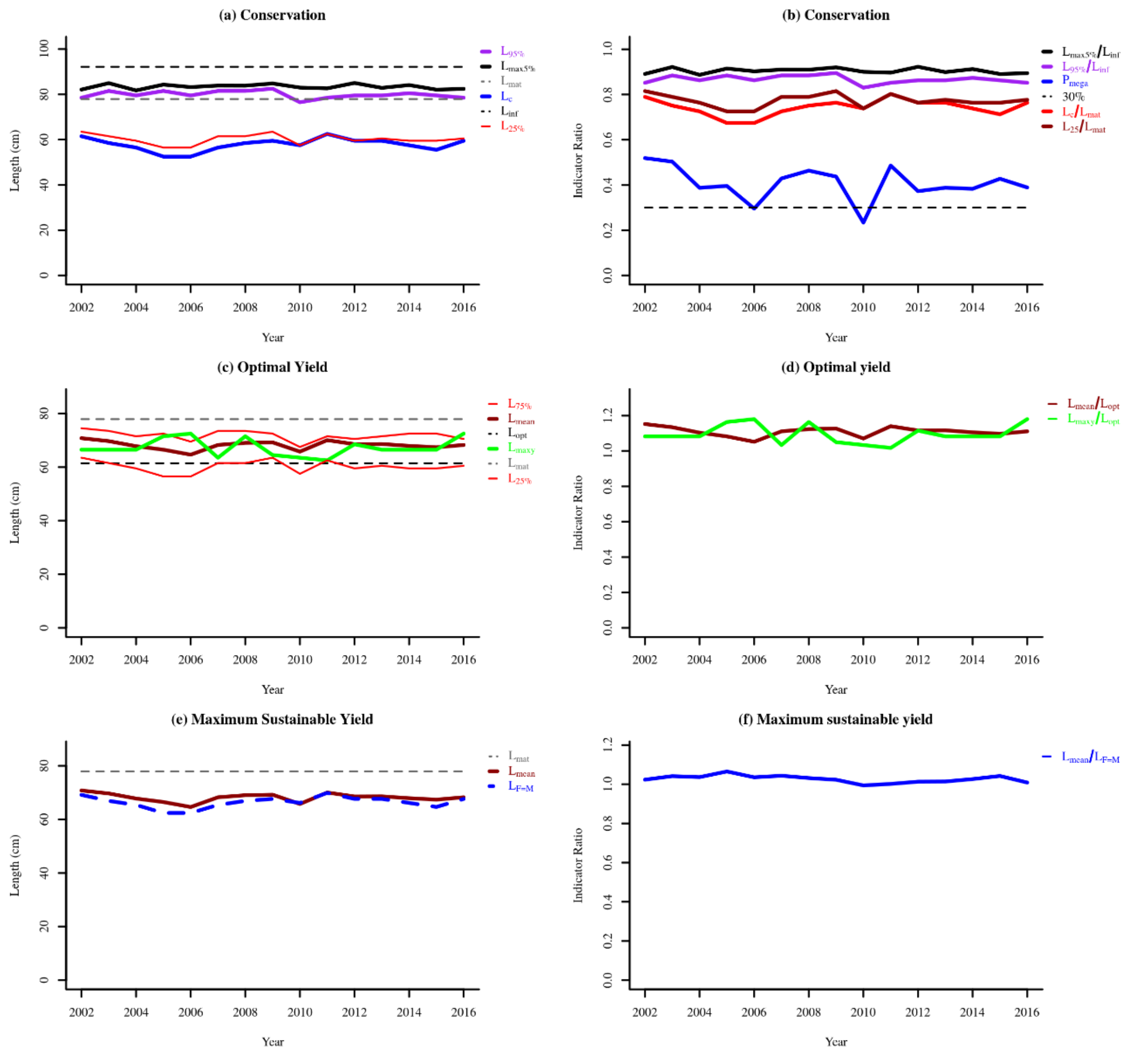

Figure 20.6. Skates and Rays in the Azores and Mid-Atlantic Ridge. Indicator ratios and reference points for *Raja clavata* from the Azorean fishery landings (2002–2016).

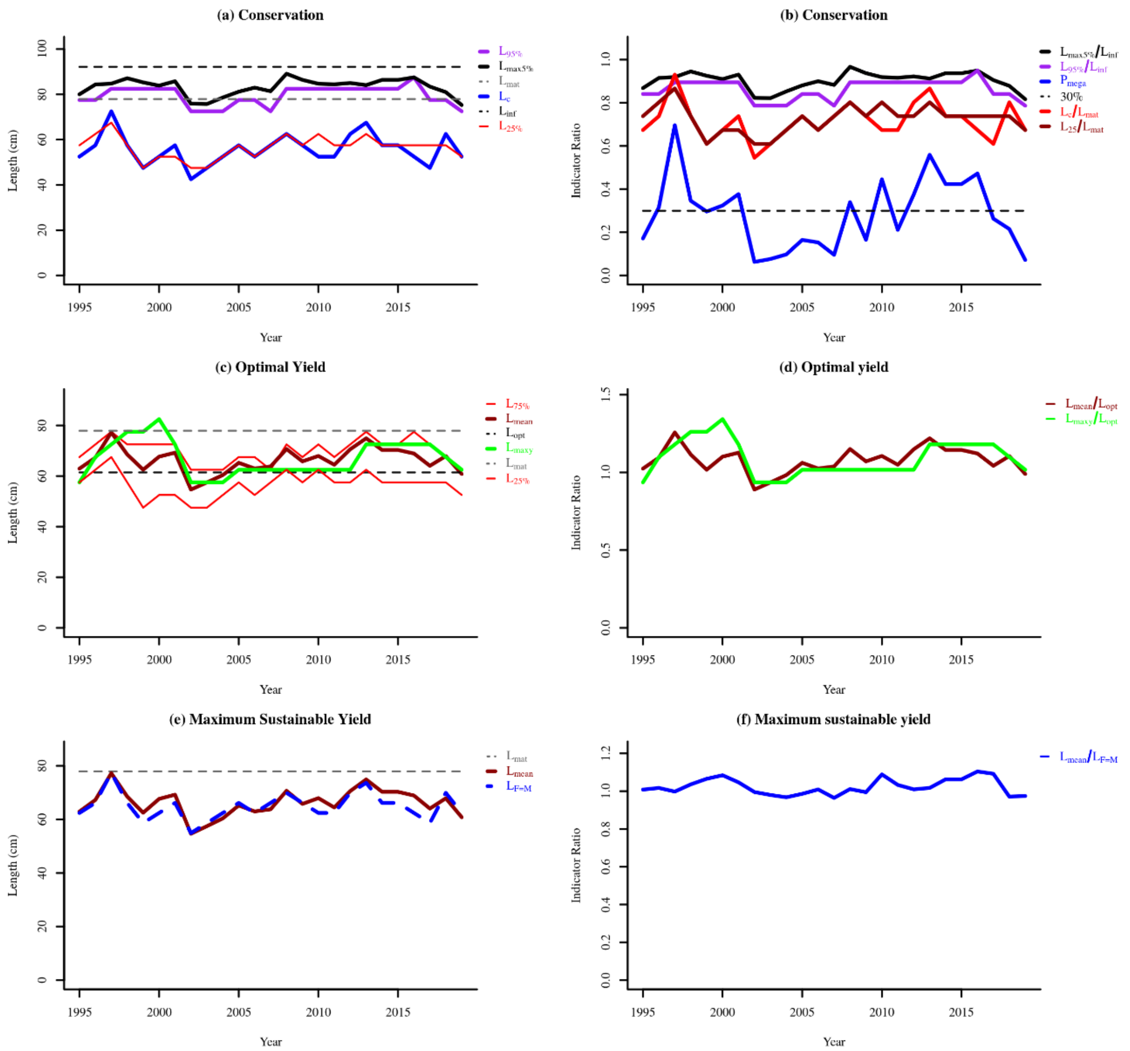

Figure 20.7 Skates and Rays in the Azores and Mid-Atlantic Ridge. Indicator ratios and reference points for *Raja clavata* from the Azorean longline survey (1995–2019).